

WHAT IS CLAIMED IS:

1. A method for analyzing the content of a biological sample, comprising:
 - a) contacting a biological sample under suitable binding conditions with a nanoporous semiconductor sensor comprising a nanoporous semiconductor structure comprising a central layer interposed between upper and lower layers, each of the upper and lower layers including from about 5 to about 20 strata of alternating porosity; and one or more first probes coupled to the porous semiconductor structure, the one or more first probes binding specifically to at least one analyte in the sample to form one or more bound complexes;
 - b) contacting the one or more bound complexes with a Raman-active probe under conditions suitable to promote specific binding thereof;
 - c) illuminating the sensor so as to cause fluorescent emissions from the sensor, the emissions generating Raman spectra from the bound complexes; and
 - d) detecting Raman signals produced by the bound complexes; wherein a Raman signal associated with a bound analyte is indicative of the presence and type of the analyte in the sample.
2. The method of claim 1, wherein the semiconductor is silicon.
3. The method of claim 1 wherein each of the upper and lower layers comprise from nine to ten strata of alternating porosity.
4. The method of claim 1 wherein the porous semiconductor structure comprises pores with an average pore size of between about 10 nm to about 100 nm.

5. The method of claim 1 wherein the first probe is a non-polymeric small molecule selected from the group consisting of avidin, peptidomimetic compounds, and vancomycin.

6. The method of claim 1 wherein the first probe is a tetratryptophan ter-cyclopentane that binds to lipopolysaccharide.

7. The method of claim 1 wherein the first probe is a polypeptide selected from the group consisting of a receptor for a cell surface molecule, a lipid A receptor, an antibody or fragment thereof, a peptide monobody, a lipopolysaccharide-binding polypeptide, a peptidoglycan-binding polypeptide, a carbohydrate-binding polypeptide, and a phosphate-binding polypeptide.

8. The method of claim 1, wherein the first probe is an antibody that binds specifically to a protein-containing analyte in the sample and the Raman-active probe comprises a secondary antibody and a Raman-active label.

9. The method of claim 1 or 8, further comprising depositing a layer of gold or silver nanoparticles having a thickness of about one-half wavelength of a light source illuminating the biosensor over the upper layer of the structure and the Raman-active probes bound thereon so that the Raman spectra generated and detected are SERS spectra.

10. The method of claim 1 wherein the sensor further comprises one or more coupling agents each comprising a first moiety attached to the porous semiconductor structure and a second moiety that binds to the first probe.

11. The method of claim 10 wherein the one or more coupling agents are silanes.

12. The method of claim 10 wherein each of the one or more first probes comprises a plurality of binding sites, at least one of which binds to the analyte and at least one of which is bonded to the second moiety of the coupling agent.
13. The method of claim 1 wherein the one or more first probes are the same.
14. The method of claim 1, wherein the first probes are a plurality of primary antibodies that bind specifically with a plurality of different protein-containing analytes and the Raman-active probes comprises a secondary antibody and a Raman-active label.
15. The method of claim 1 wherein the one or more first probes are coupled to the porous semiconductor structure throughout the central layer and the upper and lower layers.
16. The method of claim 9, wherein the SERS spectra is generated over the spectral range.
17. The method of claim 16, wherein the detecting comprises using a Fabry-Perot interferometer to transmit only certain lines of the signal while the transmitted signal is collected using a single channel detector.
18. The method of claim 17, wherein a range of the SERS spectrum is collected by tuning the transmission line of the interferometer for scanning.

19. The method of claim 1, wherein the Raman signal is generated sequentially using different excitation wavelengths to yield different spectral information regarding the analyte in the one or more bound complex.
20. The method of claim 1 or 8, wherein the sample is a bodily fluid, a suspension of solids in an aqueous solution, a cell extract, or a tissue homogenate.
21. The method of claim 20, wherein the bodily fluid is selected from urine, blood, plasma, serum, saliva, semen, stool, sputum, cerebral spinal fluid, tears, and mucus
22. The method of claim 1, further comprising: treating the sample prior to said contacting in a manner effective to disrupt the cellular membrane of cells in the sample.
23. The method of claim 22, wherein said treating comprises chemical treatment, mechanical treatment, sonication, or freezing.
24. A detection system comprising:
 - a) a nanoporous biological sensor comprising:
a porous semiconductor structure comprising a central layer interposed between upper and lower layers, each of the upper and lower layers including strata of alternating porosity;
 - b) a source of illumination positioned to illuminate the biological sensor; and
 - c) a detector positioned to capture Raman signals from complexes bound to the sensor.

25. The system of claim 24, further comprising a detector positioned to capture photoluminescent emissions from the biological sensor and to detect changes in photoluminescent emissions from the biological sensor upon binding of biological molecule to one or more pores in the structure.

26. The detection system of claim 24, wherein the source of illumination is a mercury or tungsten lamp.

27. A method of detecting the presence of a protein-containing analyte in a biological sample, comprising:

- a) contacting the sample under conditions effective to allow specific binding of a protein-containing analyte therein to at least one first probe coupled to a nanoporous biological sensor comprising:
 - a nanoporous silicon structure comprising a central layer interposed between upper and lower layers, each of the upper and lower layers including strata of alternating porosity; at least one first probe coupled to the porous semiconductor structure,the binding forming one or more bound complexes;
- b) contacting the bound complexes with a Raman-active probe that binds to the complexes;
- c) covering the bound complexes with a thin layer of silver or gold nanoparticles;
- d) illuminating the sensor so as to cause fluorescent emissions from the sensor, the emissions generating SERS signals from the bound complexes; and
- e) detecting SERS spectra produced by the SERS signals; wherein a SERS spectrum associated with a bound protein-containing analyte indicates presence of the protein-containing analyte in the sample.

28. The method of claim 27, wherein each of the upper and lower layers comprise six or more strata of alternating porosity.
29. The method of claim 27, wherein the porous semiconductor structure comprises pores with an average pore size of between about 10 nm to about 100 nm.
30. The method of claim 27, wherein the first probe comprises an antibody that binds specifically to at least one protein-containing analyte in the sample and the Raman-active probe comprises a secondary antibody and a Raman-active label.
31. The method of claim 27 or 30, wherein the first probes are a plurality of primary antibodies having specificity for a plurality of different protein-containing analytes and the Raman-active probe comprises a secondary antibody and a Raman-active label.
32. The method of claim 27 or 30, wherein the SERS signal is generated over the spectral range.
33. The method of claim 32, wherein the detecting comprises using a Fabry-Perot interferometer to transmit only certain lines of the signal while the transmitted signal is collected using a single channel detector.
34. The method of claim 33, wherein a range of spectrum is collected by tuning the transmission line of the interferometer for scanning.
35. The method of claim 27, wherein the Raman signal is generated sequentially using different illuminating wavelengths to yield different spectral information regarding the protein-containing analyte in the one or more bound complex.

36. The method of claim 27, wherein the detecting identifies at least one protein-containing analyte.
37. The method of claim 27, wherein the sample comprises urine, blood, plasma, serum, saliva, semen, stool, sputum, cerebral spinal fluid, tears, mucus, a suspension of solids in a bodily fluid, or a tissue homogenate.
38. The method of claim 37, wherein the sample is a cell suspension from a clinical isolate.
39. The method of claim 27, further comprising: treating the sample prior to said contacting in a manner effective to disrupt the cellular membrane of cells in the sample.
40. The method of claim 27, wherein the Raman tag is selected from adenine, 4-amino-pyrazolo(3,4-d)pyrimidine, 2-fluoroadenine, N6-benzolyadenine, kinetin, dimethyl-allyl-amino-adenine, zeatin, bromo-adenine, 8-aza-adenine, 8-azaguanine, 6-mercaptopurine, 4-amino-6-mercaptopyrazolo(3,4-d)pyrimidine, 8-mercaptopadenine, or 9-amino-acridine.
41. A method for analyzing the content of a biological sample, comprising:
 - a) contacting a biological sample under suitable binding conditions with a nanoporous semiconductor sensor comprising a nanoporous semiconductor structure comprising a central layer interposed between upper and lower layers, each of the upper and lower layers including from about 5 to about 20 strata of alternating porosity; and one or more first probes coupled to the porous semiconductor structure, the one or more

first probes binding specifically to at least one analyte in the sample to form one or more bound complexes;

- b) contacting the one or more bound complexes with a fluorescence-active probe under conditions suitable to promote specific binding thereof;
- c) illuminating the sensor so as to cause fluorescent emissions from the sensor, the emissions generating secondary fluorescent emissions from the bound complexes; and
- d) detecting the secondary fluorescent emissions produced by the bound complexes; wherein a secondary fluorescent emission associated with a bound analyte is indicative of presence and type of the analyte in the sample.

42. The method of claim 41, wherein the first probes are a plurality of primary antibodies that bind specifically with a plurality of different protein-containing analytes and the fluorescence-active probes comprises a secondary antibody and a fluorescent label.

43. A method for analyzing the content of a biological sample, comprising:

- a) contacting a biological sample under suitable binding conditions with a nanoporous semiconductor sensor comprising a nanoporous semiconductor structure comprising a central layer interposed between upper and lower layers, each of the upper and lower layers including from about 5 to about 20 strata of alternating porosity; and one or more first probes coupled to the porous semiconductor structure, the one or more first probes binding specifically to at least one analyte in the sample to form one or more bound complexes;
- b) illuminating the sensor so as to cause optical emissions from the analytes in the bound complexes;
- c) detecting the optical emissions produced by the analytes in the bound complexes; wherein an optical emissions provides information concerning the presence and type of analyte in a bound complex.

44. The method of claim 43, wherein the analyte is a protein-containing analyte or a DNA molecule.

45. The method of claim 44, wherein the optical emissions are Raman signals.

46. The method of claim 44, wherein the optical emissions are fluorescence.